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(Control Number)

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PAR 170B

Advanced Printer  
for  
Continuous Exposure Control

12 March 1969

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NIMA/DOD

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Total Pages: 11

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## PROJECT AUTHORIZATION REQUEST

PAR 170B

12 Mar 69

SUBJECT: Advanced Printer for Continuous Exposure Control

## TASK/PROBLEM

1. Develop, fabricate, and evaluate a new continuous-printer bread-board that incorporates a built-in optical scanner, suitable programmable logic, and a controllable light source to provide a continuously variable exposure control along the length of the film being printed.

## PROPOSAL

2. Introduction:

a. Exposure variations in aerial photography require exposure compensation in the duplicate printing operation to produce the most desirable reproductions. In general, the purpose of compensation is to reproduce the density range of the negative on a particular portion of the D Log E curve for the duplicate material. In many cases, however, this is difficult or impossible because frame-to-frame density variation can require consecutive frames to be printed at different exposure levels, or the density range within a frame is too great to reproduce at a single level. In the present production system, both of these conditions require dual printing (two separate prints at two different printing conditions). To reduce the need for dual prints, development effort to date has been largely aimed at achieving interframe control. Although such control is feasible, it is not being used in the production system because of the long delays necessary to establish a machine-readable address (in binary code) on each frame of film and to prepare and check a detailed frame-by-frame exposure instruction (punched paper tape) for the printer. While this situation might be improved somewhat by the use of recently developed scanner and computing techniques, the basic goal of printing each frame at a fixed exposure should be re-examined.

SECRET

PAR 170B

12 Mar 69

b. Present-day production techniques consist of manual densitometry of the original negative and the breakdown of that photography into parts requiring a common printer exposure. Although it is desirable to make these parts be as long as possible to increase printer efficiency, in many cases the density "swings" could require breakdown to very short lengths. In addition, even when short lengths are used, a single exposure setting must always be somewhat of a compromise. When this compromise becomes unacceptable in terms of information loss, dual printing is used, and a given part receives two different exposures that together result in the maximum information transfer. These conditions are shown graphically in Figures 1 and 2.

(1) Figure 1 represents a plot of density data for consecutive frames of typical aerial photography. Each vertical line represents the density range found within that frame. The horizontal dashed lines represent the boundaries of good reproduction for specific exposure levels. The general trend of densities from one exposure level to another is representative of that found in a J mission and requires cutting the negative and inserting leader material at the point of exposure change.

(2) Figure 2 is a similar plot, typical of a G mission, in which there may be large frame-to-frame density swings requiring dual printing under the present system. Dual printing, of course, represents additional effort, material, and time in the production system. In general, the more exposure variation there is in the original from frame-to-frame, the shorter the parts will have to be and the greater the need for dual printing. In considering how suitable today's production system might be to handle new missions with very long lengths of film, it appears that dual printing could become a real system bottleneck.

25X1

PAR 1708  
12 Mar 69

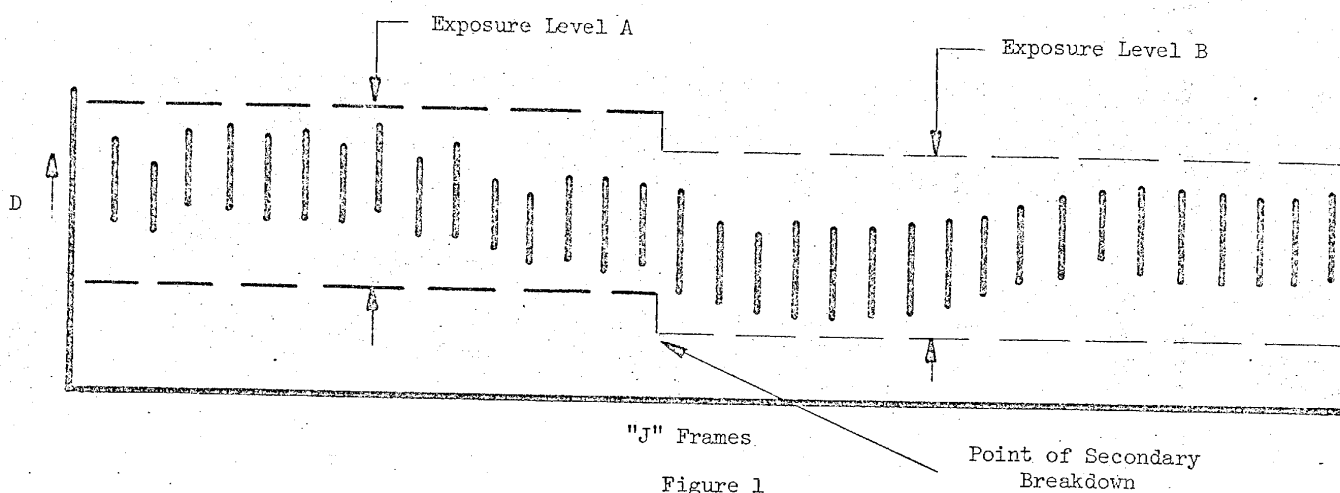


Figure 1

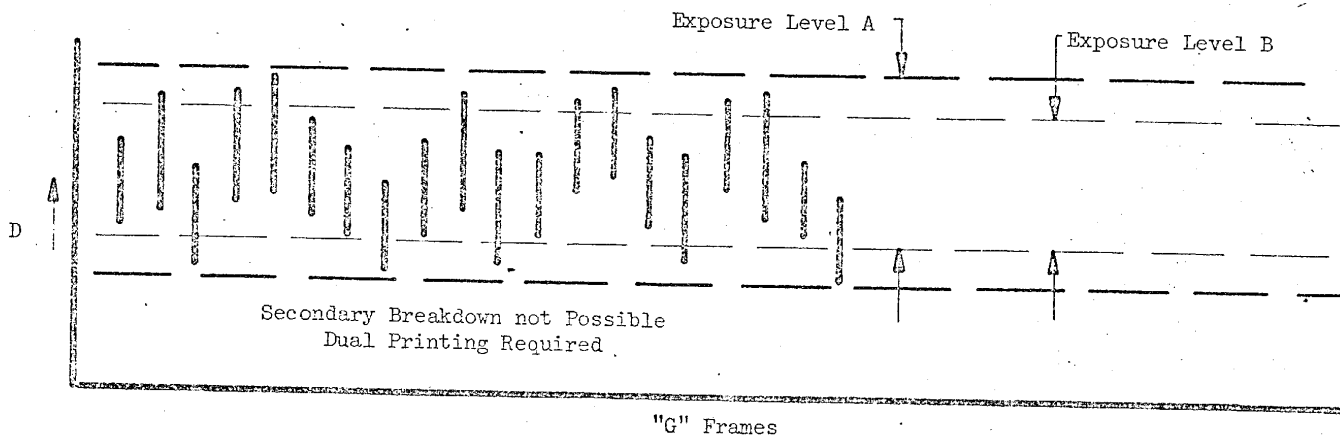


Figure 2

SECRET

PAR 170B

12 Mar 69

25X1

c. Much past and present development work contributed to this proposal for a continuous-exposure-control printer. The [ ] Frame by Frame Printer (PART XIX, Item 6) demonstrated the feasibility of frame by frame exposure control and the production shortcomings of such a system; the [ ] Step-and-Repeat Drum Printer (PAR 52B) demonstrated the feasibility of automatically producing dual prints; the Drum Printer with Modulated CRT Source (PAR 107B) indicated that there were serious problems associated with dodging, but it produced encouraging results with exposure control; unfortunately, resolution and speed limitations discouraged this last approach. PARs 61B, Improved IR Scanner, and 70B, Film Scanner Recorder, developed new film scanners and PAR 24-7-7S/R1, Study of Scanning Techniques, is continuing the study of problems associated with automatic establishment of proper processing and printer control. PAR 146S/R2, Printing Exposure Modulation Study, has produced a rapid, accurate intensity control for the mercury-arc source that is common to black-and-white printers.

d. Continuing work on the PAR 70B Scanner (under a separate contract) using an operating standard developed under PAR 24-7-7S/R1, has demonstrated that printer exposure control decisions that equal or exceed the present accuracy of manual densitometry can be made automatically on a part basis. Work is continuing in this area and minor printer modifications are being made to permit the production system to take maximum advantage of this system. These modifications permit construction of composite negative rolls in which adjacent sections requiring different printer exposure are separated by a section of leader material appropriately marked to indicate the exposure level change. This leader material is long enough to permit the operator to change exposure level conveniently and without having to stop the printer. Preliminary trials indicate a significant increase in production efficiency using these techniques; nevertheless, the decisions continue on a part-by-part basis and dual printing requirements will, of course, remain.

PAR 170B

12 Mar 69

d. The rationale for a scanning printer stems from the successful development effort summarized below. PAR 24-7-7S/R1 has produced a satisfactory method of automatically predicting exposure requirements. PAR 70B has produced a stable, reliable, high-speed scanner capable of reading a wide density range using a multiplicity of one-half millimeter spots. Small, relatively inexpensive logic units are now commercially available to process scanner information. PAR 146S/R2 has produced a high-intensity, rapidly controllable source. All of these developments are compatible with a 100 ft/min printer with resolution equal to that of the present [REDACTED]

25X1

e. Test information available today indicates that this system would be successful if programmed to respond on either a part basis or a frame basis; however, practical difficulties would be encountered in such a scanning printer, since both of these programs (part or frame) would require delineating and scanning the complete length on which the decision is to be based. In the case of [REDACTED] material printed on a frame basis, this could require locating the scanner some 130 inches ahead of the exposure station and sufficient memory to store all scanned data for a given frame before data processing begins. The logic for a continuous exposure control scanning printer is essentially that exposures can now be predicted automatically and accurately on either a part or frame basis. Because this is true, it is believed that such exposures might be even more accurately predicted on an incremental basis (such as a two-inch length of film). If this can be confirmed, then a short-coupled scanner-printer responding to intraframe density variations is entirely practical. A simple schematic diagram of such a printer is shown in Figure 3.

25X1

f. The advantages of such a printer are immediately apparent, and would result in the following benefits:

(1) Any original negative material could be immediately printed without the need for prior densitometry, auxiliary identifying marks on the film, or accompanying printer instructions.

SECRET 25X1

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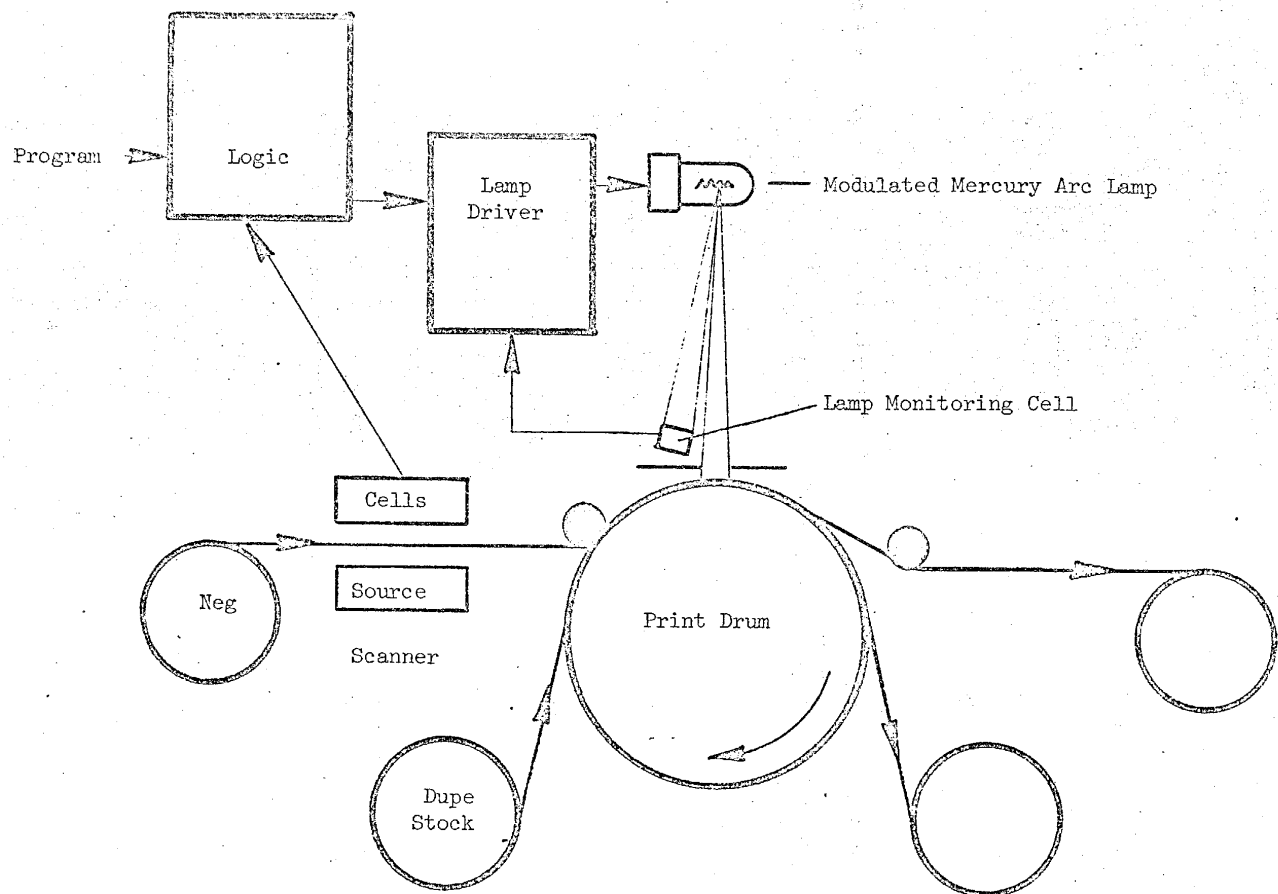


Figure 3. Schematic of Advanced Printer for Continuous Exposure Control

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25X1

PAR 170B

12 Mar 69

(2) Overall print quality should be improved by the incremental approach. In Figure 4, a typical density plot by increment for a single frame is shown. While it is obvious that a fixed exposure (level A) would satisfactorily print this frame using today's standards, it is equally apparent that not all increments are well centered about the point of best overall quality. The incremental approach has the inherent ability to expose each increment, not only on the straight line portion of the curve, but at the optimum part of that straight line section.

3. General Approach. It is proposed that a scanning printer be developed based on the principles described above and shown schematically in Figure 3. This printer would provide a continuous mode of printing, as in a [redacted], however, its design would include a scanning head and appropriate logic units necessary to control the variable exposure source as required by the density of the original material on an intraframe or incremental basis. Such a printer could eliminate the need for manual densitometry and the need for any local machine-readable address on the original material, since its decisions would be based on density alone. It should also reduce appreciably the need for dual prints.

a. The first step in this program will be a short re-evaluation of today's scanner data as it would apply to increments of film rather than frames or parts. We will attempt to select an exposure increment of reasonable size consistent with printer design and desired response.

b. Following this decision, we will select and order appropriate logic hardware which will permit reasonable variations in criteria.

c. Concurrent with step b. the basic printer components will be laid out and fabrication will be started. Since all printer components have been proven individually on other PARs, no development problems are expected with hardware.

d. Following final assembly and engineering checkout, a detailed evaluation program is planned to further refine the criteria and to learn the production problems associated with such a printer. Some questions that will require answers are:

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25X1



25X1

12 Mar 69

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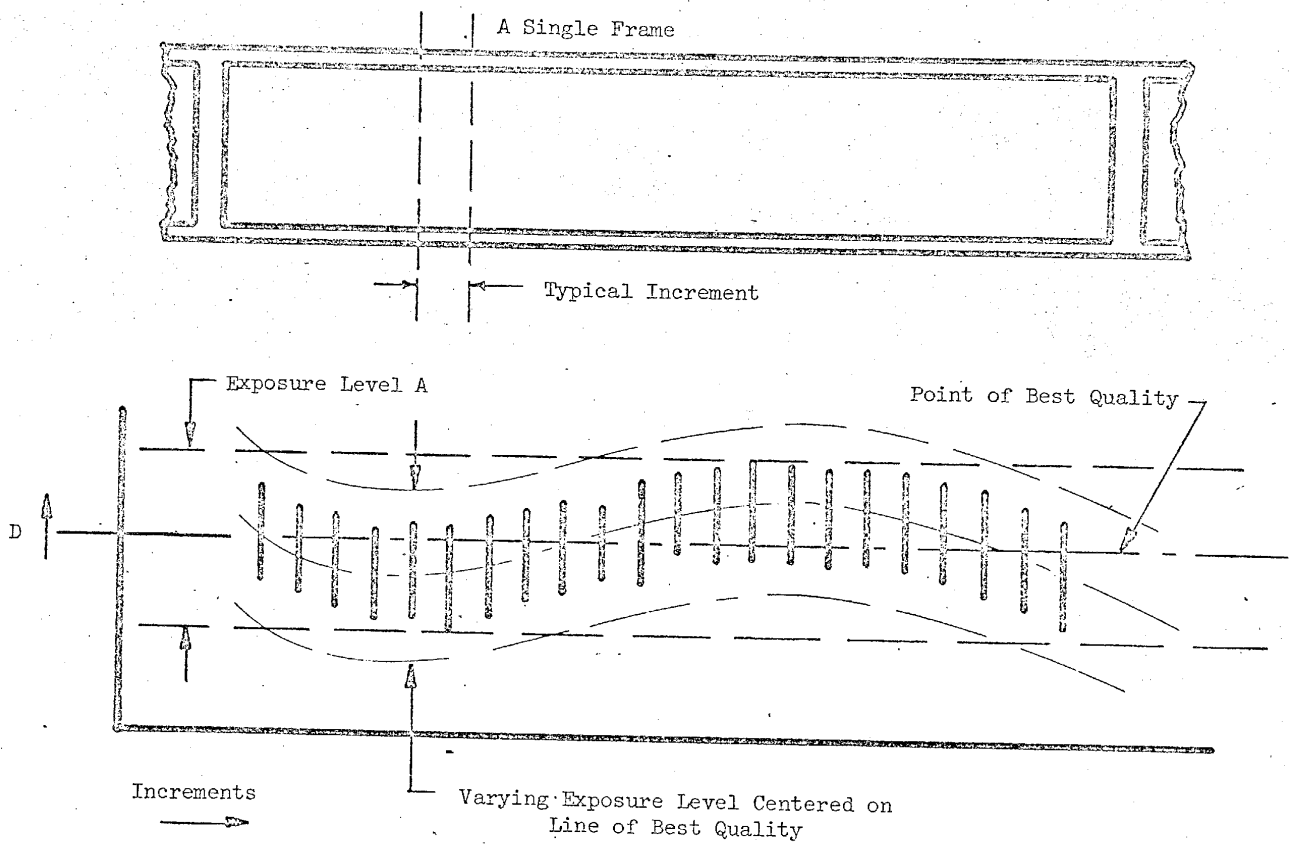


Figure 4

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PAR 170B

12 Mar 69

- (1) How will such a printer be checked for control?
- (2) What errors will the printer make and how can they be corrected?

#### PROGRAM OBJECTIVE

4. The objectives of this program are listed below.
  - a. Use existing technology to develop, fabricate, and assemble a continuous exposure control printer incorporating (1) standard  film transports capable of handling 70mm to 9.5-inch-wide film, (2) a scanner similar to that of PAR 70B, (3) a separate logic unit for processing density data, and (4) a programmable light source similar to that of PAR 146S. This printer is to be capable of continuous printing at 100 ft/min and of applying continuous exposure control; this control will be based on density data processed and analyzed by the logic unit in general accord with presently available techniques.
  - b. Evaluate the printer under production conditions.
  - c. Make recommendations for follow-on activity.

25X1

#### SCHEDULE

5. A tentative schedule covering the major phases of effort is shown in Figure 5. Changes in this schedule, that may be necessary as the work progresses, will be reviewed with the CCB.

12 Mar 69

# TENTATIVE SCHEDULE

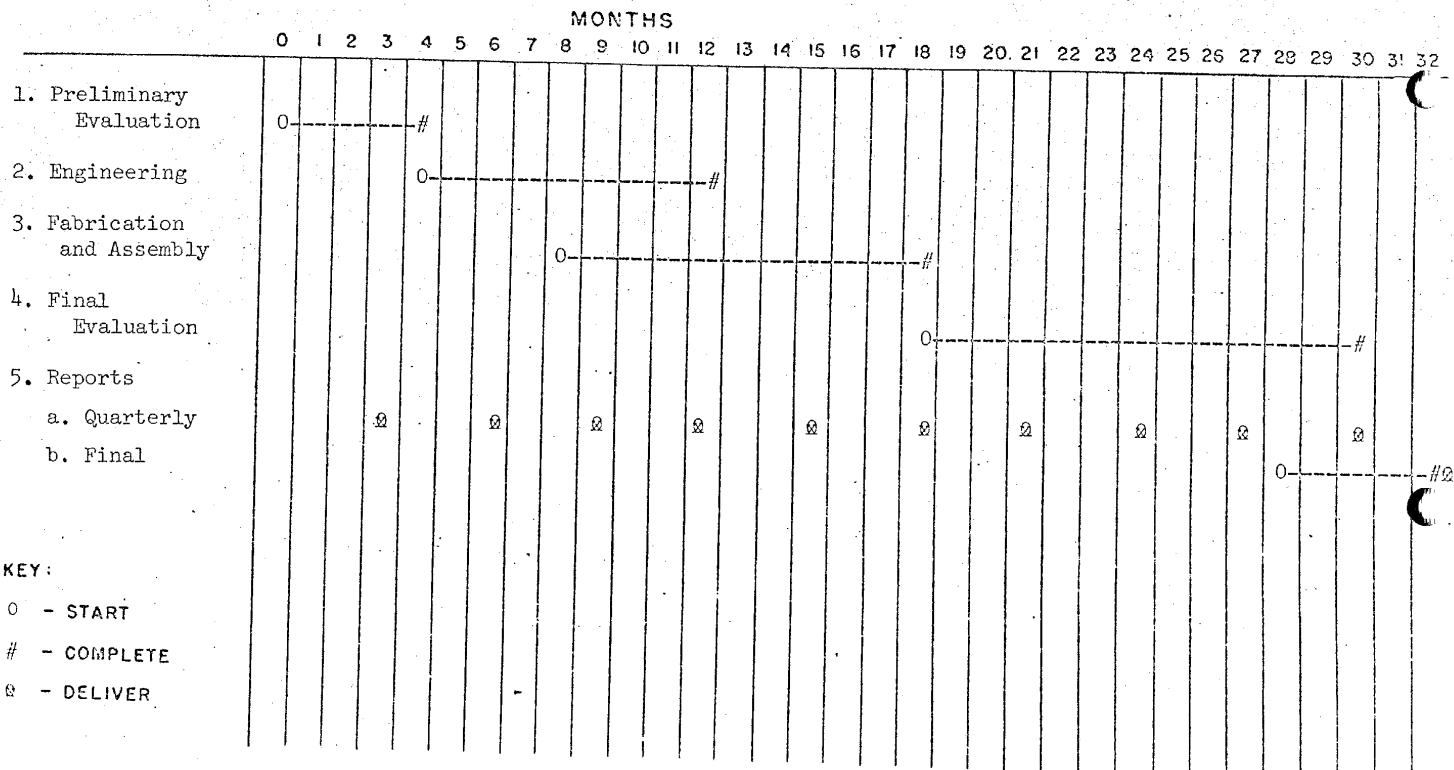


Figure 5

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